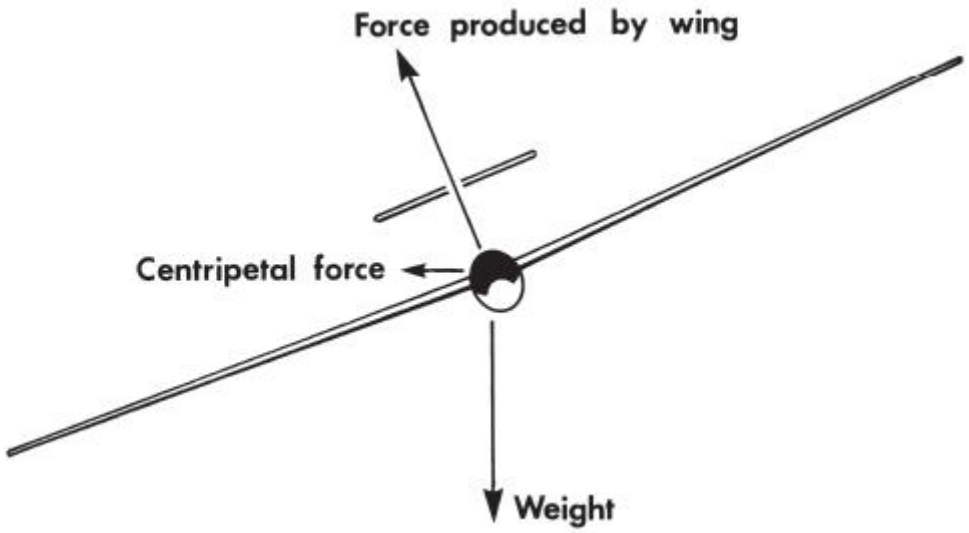
TURNING

The Forces in a Turn

Consider what happens when you are in a car going round a corner at speed. You find yourself pressed against the side of the car which is on the outside of the turn. This is due to the natural tendency of any moving body - in this case yourself - to continue to move in a straight line unless an external force is applied to it. The framework and the seat of the car produce a force on you which carries you round the corner. The car itself has also a tendency to go straight on, but the necessary force to cause it to go round the corner is provided by the steering and the friction of the tyres on the road.

The force acting towards the centre of the turn which is required to keep a body moving in a circle is known as the "centripetal force".

When an aircraft turns, the centripetal force is provided by part of the lift of the wings. This is done by banking the aircraft in the direction of the turn, so that the lift is able to provide a component towards the centre of the turn. The magnitude of the centripetal force required varies with the rate of turn and with the airspeed.



The weight of the aircraft still has to be supported during the turn; in order to do this as well as provide the necessary centripetal force, the total lift must be increased. As explained earlier, the "load factor" is now greater than one.

When a gentle turn is carried out with no alteration of airspeed, the increased lift is provided by the increased angle of attack. This means that the angle of attack is nearer the stalling angle, and if a greater rate of turn is attempted, ie, more bank, the critical angle of attack may be reached in trying to provide the necessary lift. This will result in a stall at a comparatively high airspeed, as mentioned previously. For example, a glider with a "stalling speed" of 30 kt. will stall at 42 kt. in a turn at 60° bank.

When carrying out steeper turns, the risk of an accidental stall should be reduced by increasing the airspeed before beginning the turn.

Hence an increase in speed can be used to provide the extra lift needed. The main principles of turning are summarised as follows:

1. At a fixed airspeed the rate of turn and the size of the turning circle depend upon the angle of bank. This angle of bank determines the proportion of the total lift providing the centripetal force. For a certain rate of turn at a given airspeed there is only one angle of bank.

2. As the angle of bank is increased the wing loading becomes greater. This involves an increased stalling speed and an increased rate of sink.

Use of the controls in the turn

In carrying out a correct turn, we must use the controls so that the lift component providing the centripetal force always points in the direction we wish to turn. The aircraft must therefore be banked to the amount appropriate for the desired rate of turn.

The amounts of pitch and yaw are regulated to produce the required flight path. The relative amounts needed vary with the steepness of the turn. In a well-designed glider a large part of the yawing movement required is provided by the weathercock stability.

The use of the ailerons.

In a turn the ailerons are used to keep the bank constant at the amount appropriate for the required rate of turn (e.g. 20° - 30° of bank for a medium turn).

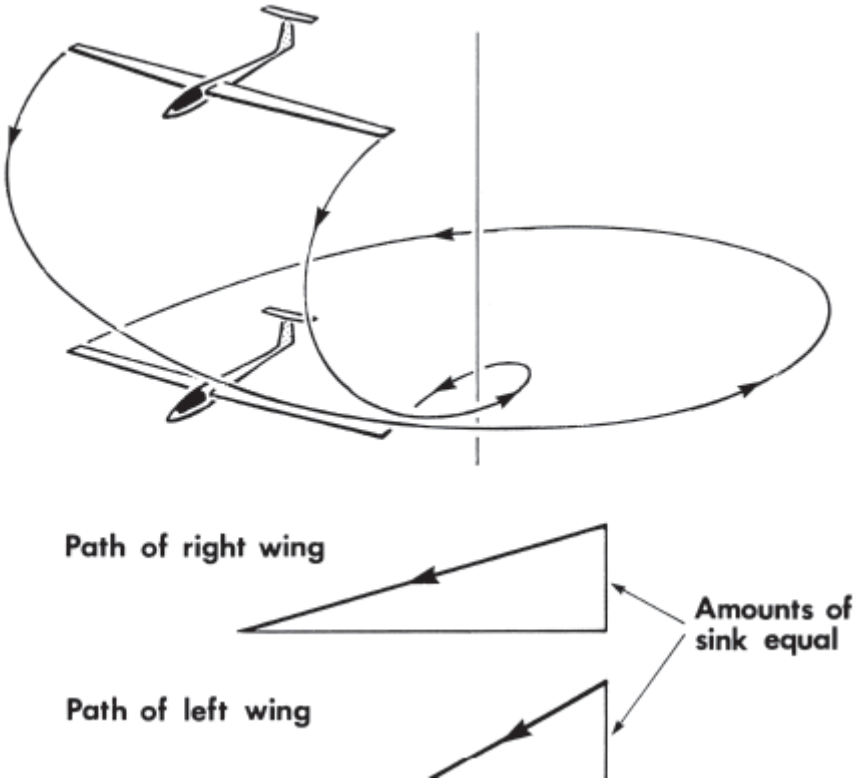
There are two effects which tend to alter the angle of bank during a turn. these are:

1. The outer wing in a turn is travelling faster than the inner wing, as it is further away from the centre of the circle. This results in greater lift on the outer wing, which tends to increase the angle of bank.

2. Relative to the air, a glider descends as it turns; after the turn both wings have descended the same amount, but the outer wing, as mentioned above, travels further than the inner wing during the descent. It has therefore followed a flatter path than the inner wing.

Diagrammatically, the paths followed by the two wings are shown below. (The spiral paths have been straightened out for comparison). It is apparent that the inner wing, making the steeper descent, presents a greater angle of attack to the airflow than does the outer. The inner wing therefore generates more lift and the effect is to reduce the angle of bank.

In a glider, these two effects more or less cancel each other out, so that once the bank has been adjusted, the ailerons are kept roughly in the neutral position. However, it is not necessary to think of the position of the stick; merely use the ailerons as necessary to keep the bank constant.



The use of the elevator

In a turn, as in level flight, the elevator is regarded as controlling the position of the nose above and below the horizon, and hence holding an attitude and thereby keeping the airspeed at the chosen figure. By doing this, the extra lift and the required pitching movement are provided. For gentle turns a very slight backward pressure on the stick is necessary. For steep turns rather more pressure is needed and care should be taken to avoid the nose dropping on entering the turn. Once a steep turn is established a backward movement of the stick will tighten up the spiral without reducing the airspeed, and in order to raise the nose it is necessary first to reduce the bank; the speed can then be reduced and the turn steepened again, making sure that the nose does not drop to its previous attitude.

The use of the rudder

The rudder is best thought of as a secondary control used to correct slip or skid. In a correct turn the aircraft should always be flying straight into the airflow rather than sideways. If you carry out a turn with too much rudder (i.e. a "flat" turn) you cause the aircraft to "skid" outwards. This results in a sensation of being pressed towards the outside of the turn. The aircraft is in fact being made to travel broadside through the air. This is an inefficient condition which will cause unnecessary loss of height and will not get you round the turn easily. On the other hand, if you attempt a turn without using any rudder, the aircraft will "Slip" inwards when it is banked over. You will then feel a tendency to slide inwards on your seat.

This slipping and skidding is thus due to the incorrect co-ordination of the rudder movement with the movement of the ailerons. You can correct a skid either by using less rudder or more bank. However, you will find it easier to use the ailerons to keep the bank constant and the elevator to

keep the speed correct. If you are skidding outwards, you applied too much rudder; if you are slipping inwards, you have not enough.

How to carry out a turn

The actual manoeuvres involved in a turn should be carried out in three parts, namely, going in, staying in and coming out. Before starting any turn **always have a good look around**, particularly in the direction of the turn as you may be turning across the path of another aircraft. You should always be keeping a good lookout for other aircraft.

1. Going in: look around, especially in the direction of the turn. Then, to go into turn to the left, move the stick gently to the left to start banking the glider. At the same time as you apply the bank, apply sufficient left rudder to prevent the nose yawing to the right (thus counteracting the adverse yaw). When you have the required angle of bank, centralise the ailerons and reduce the amount of rudder. As the aircraft banks apply a gradual backward pressure on the stick to keep the airspeed correct by keeping the nose at the correct attitude relative to the horizon.

2. Staying in: continue to look around. Keep the angle of bank constant by use of the ailerons and rudder as required. If the turn is balanced (i.e., no slip or skid) and the speed is steady the nose will keep moving smoothly round the horizon. If the nose rises or falls, correct with the elevator (but remember to reduce the angle of bank before trying to raise the nose in a steep turn. If you find yourself slipping or skidding, correct with the rudder; less rudder is needed once the turn is established**. Look around frequently**.

3. Coming out: look around, especially in the direction the glider will fly out of the turn. Move the stick in the direction opposite to that of the bank, with some rudder in the same sense, until the wings are level. When the aircraft straightens up, centralise the stick and rudder. Relax the backward pressure on the stick as the bank reduces to keep the airspeed correct; otherwise there is a tendency for the nose to rise on coming out of a turn (particularly a steep turn).

Airspeed in a turn

You will remember that the stalling speed of the aircraft is increased during a turn. You will probably be taught to fly at a normal cruising speed which provides an adequate margin for gentle turns, in which case no alteration of speed is necessary. For steeper turns (above 30° of bank) it is advisable to fly a little faster than usual; the nose must then be kept in a lower attitude relative to the horizon by the appropriate use of the elevator.

Faults in a turn

The faults occurring in turns may take the following forms:

1. Not keeping the bank constant.

2. Movement of the nose up or down rather than holding the correct attitude.

3. Skidding or slipping.

A turning fault can be caused in more than one way. For instance, if you are slipping in during a turn, it may be due to too much bank or too little rudder. However, if each control is considered as having its own function, as outlined above, any fault can easily be corrected. In this case, if the angle of bank and the position of the nose is correct, you must correct any slip by applying more rudder. The application of rudder on its own will cause the bank to increase (secondary effect of rudder) and the nose to drop (the yaw axis is now tilted in relation to the ground). You will need to stop the bank and

speed increasing by appropriate movement of the stick. For a smooth turn all three controls must be moved in close harmony. This appears to be a formidable procedure when set down on paper, but co-ordination is soon achieved by practice! A common issue for new pilots is looking into the turn when rolling into a turn. Your instructor will advise you to look ahead when rolling in and out of a turn – all the information you need is in front of you!

To summarise

For an accurate turn:

1. **Lookout carefully** before turning. Then look ahead.
2. Use the ailerons (with rudder of course!) to roll into the turn and then to maintain the correct bank angle.
3. Use the elevator to maintain the correct pitch attitude to give the required airspeed.
4. Counteract slipping or skidding with the rudder. If you are skidding, use less rudder; if you are slipping, use more.

Maintain good lookout in the turn and before leaving the turn, as taught by your instructor.